TEMPORAL CHANGES IN THE ECOLOGICAL CONDITIONS OF NON-TIDAL STREAMS IN LIBERTY RESERVOIR, MATTAWOMAN CREEK, AND PRETTYBOY RESERVOIR WATERSHEDS

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WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT
CBWP-MANTA-EA-03-5

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FINAL DATA REPORT

Temporal Changes in the Ecological Condition of Non-Tidal Streams in Liberty Reservoir, Mattawoman Creek, and Prettyboy Reservoir Watersheds

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FOREWORD

The Maryland Department of Natural Resources (MDNR), Monitoring and Non-tidal Assessment Division prepared this report with financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the National Oceanic and Atmospheric Administration (NOAA). This technical memorandum was funded in part by MDNR's Coastal Zone Management Program pursuant to NOAA Award No.NA070Z0118. In the past, Coastal Zone Management Program funds have been used to help support data collection as well as to prepare interpretive reports on the ecological condition of streams in each drainage basin within Maryland's Coastal Zone. This project continues the process of providing stream monitoring information that is necessary for watershed restoration and protection in the Coastal Zone.

EXECUTIVE SUMMARY

Temporal changes in the ecological condition of non-tidal streams within Liberty Reservoir, Mattawoman Creek, and Prettyboy Reservoir watersheds were examined using data collected by the Maryland Biological Stream Survey from 1995 to 2000. Except for dissolved oxygen concentrations in Prettyboy Reservoir, no significant differences were found in ten chemical, physical, and biological parameters among sample years within the watersheds. Subtle differences in the variables (i.e. distribution, range, mean values) among years were observed. These subtle differences were discussed in the context with differences in sample site distribution and precipitation among sample years. To more conclusively ascertain whether or not changes are occurring in the ecological condition of streams within these watersheds and to identify probable causes responsible for these changes requires a longer time series of data and updated land use information. In addition, the establishment of stationary sample sites may reveal annual variability in parameters for each of the study watersheds.

Introduction

The randomized selection of sample sites used in the Maryland Biological Stream Survey study design provides the opportunity for the assessment and characterization of the overall ecological condition of streams within a watershed. To examine temporal trends in the ecological condition of streams in three Priority 1 watersheds (Liberty Reservoir, Mattawoman Creek, and Prettyboy Reservoir) located in Maryland's Coastal Zone, the present ecological condition of watersheds as observed during 2000 MBSS sampling was compared to the condition observed during previous MBSS sampling (1995-1999). Comparisons of water chemistry, physical habitat, and biological quality between sample years were performed in each watershed. Results from these comparisons and recommendations for future research in these three watersheds are presented in this report.

Methods

Sampling of non-tidal streams within Liberty, Mattawoman, and Prettyboy watersheds took place from 1995 through 2000. The number of sites and sample years for each watershed are listed in Table 1.

Table 1.

8-Digit Watershed	Total Acreage of Watershed	Sample Year	# of Sites
Liberty Reservoir	104,804	1995 1996 2000	19 18 16
Mattawoman Creek	62,192	1999 2000	22 11
Prettyboy Reservoir	46,455	1996 2000	9 10

Chemical, physical, and biological sampling took place at each site during each sample year. Water chemistry, physical habitat, and biological data were collected using methodologies developed for the Maryland Biological Stream Survey (MBSS). For further details on sampling protocols and descriptions of physical habitat measures, refer to the Maryland Biological Stream Survey Sampling Manual (Kazyak 2000).
To investigate temporal changes in the ecological conditions of streams in these three watersheds, ten parameters were selected for analysis: three water chemistry parameters including nitrate, dissolved oxygen, and pH; five measures of physical habitat quality including instream habitat, epifaunal substrate, pool/glide/eddy quality, riffle/run quality and riparian buffer width; and two biological indices, the benthic and fish indices of biotic integrity developed from the MBSS database (Roth et al. 1999). These parameters tend to be useful indicators of anthropogenic influence and are expected to reflect trends

in ecological condition of the streams occurring in each watershed. Thresholds used for classifying chemical, physical habitat, and biological values are listed in Appendix A.

With the exception of riparian buffer width, box and whisker plots were used to illustrate the distribution of data for nine parameters in each watershed for each sample year. Box and whisker plots represent the distribution of data in the following way. The box on each plot represents the 25th and 75th percentiles. The vertical lines extending through the box represent the data range for that year. The black ovals along these vertical lines represent the 10th and 90th percentiles. The dark cross represents mean values per year. Categorical thresholds used to define habitat or biological quality are also included on the box and whisker plots. Refer to Figures 1 and 2 for further clarification of the box and whisker plots.

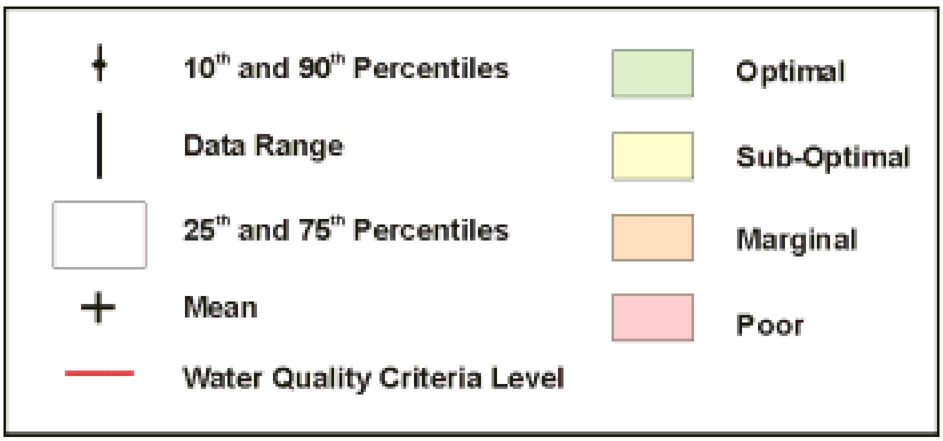

Figure 1. Legend and definition of symbols used for the water chemistry and physical habitat box and whisker plots. Colored boxes represent the categorical thresholds used to define physical habitat quality (Appendix A).

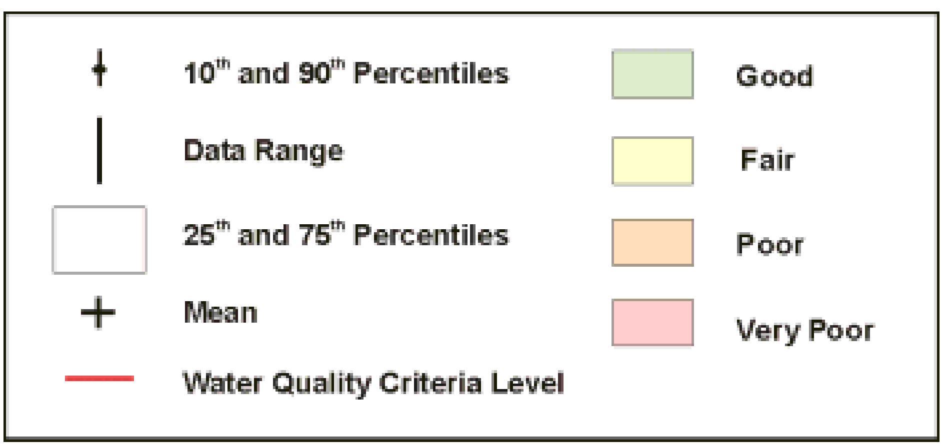

Figure 2. Legend and definition of symbols used for the Fish and Benthic Biotic Indices box and whisker plots. Colored boxes represent the thresholds used to define the biological index values (Appendix A).

Trends in ecological condition were separated from random annual variability using a visual analysis of the box and whisker plots. This visual technique was adapted from methods using 25th and 75th quartile overlap as indication of significance (Tukey 1977). For this analysis, 10th and 90th percentiles were used as a more conservative measure of significance due to small sample size within some of the study watersheds. Overlaps in 10th and 90th percentiles indicated that no significant differences in parameter values were evident between sampling years. Separation of percentiles was reasonable indication that significant differences existed between sample years (Perry 2001). For example, the 10th and 90th percentiles for the Fish Index of Biotic Integrity (FIBI) in Hypothetical Watershed A ranged from 2.5 to 5.0 in 1999. In 2000, percentiles ranged from 1.25 to 4.0. These values overlap, meaning that no significant differences in FIBI values existed in Hypothetical Watershed A between these two years (see Figure 3). However, if the 10th and 90th percentiles in 2000 ranged from 1.25 to 2.0, no overlap in percentile values would occur. This would indicate that significant differences existed between the two years (see Figure 4).

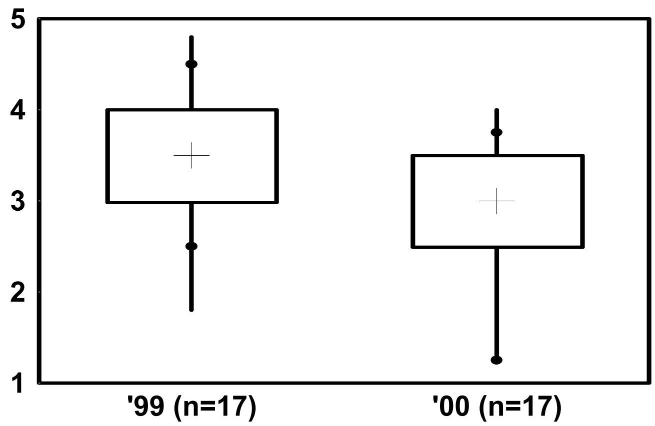

Figure 3. Plot representing overlap in the 10th and 90th percentiles between years for Hypothetical Watershed A. For the purpose of this report, no significant differences exist between sample years.

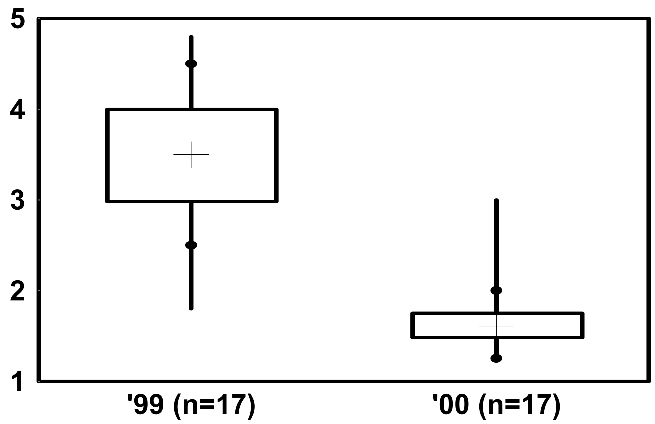

Figure 4. Plot representing no overlap in the 10^{th} and 90^{th} percentiles between years for Hypothetical Watershed A. Significant differences exist between sample years.

Changes in riparian buffer width and composition between years were compared using standard bar graphs. No test of significance was used in the riparian buffer comparisons.

Results and Discussion

At least two factors, including sample site distribution and annual variability in precipitation, may influence the values of the ten selected parameters used in the comparisons of stream conditions between years. Prior to interpreting box and whisker plots and riparian buffer bar graphs, annual variability in site distribution and precipitation between years was examined for each watershed.

Annual Variability in Site Distribution

Differences in the spatial distribution between years of randomly-selected sites with respect to land use could result in differences in the overall assessment of the watershed. For example, sites within predominantly agricultural and urban areas tend to be negatively influenced by a myriad of stressors (i.e. point source and non-point source pollution, influx of fine sediment, flashy stream flows, increased water temperature) introduced by human activity across the landscape. The biotic and abiotic characteristics of these streams may often be different from the characteristics of a stream found within a predominantly undisturbed, forested watershed. If the percentage of sites falling within each of these land uses differs between years, the assessment of the ecological conditions of the watershed may be effected. The potential effects of differences in site distribution between sampling years on the detection of temporal changes in watershed condition were investigated in three watersheds (Liberty Reservoir, Prettyboy Reservoir, and Mattawoman Creek) for this CZM supported project.

Digitized land cover data from 1993 Landsat imaging (MRLC 1996) were used to examine sample site distribution in the three watersheds. The percentage of sites for each sampling year falling into four land use categories (Forest, Agriculture, Urban, and Other) was calculated. Differences/similarities in the percentages of sites in land use categories were examined and identified. It is important to note that this site distribution analysis was performed using land use data from only a single year. The results do not reflect changes in land use that have occurred in all three watersheds since 1993. Differences in the percentages of sites in the four land use categories indicate differences in the spatial distribution of the sites. For example, by chance, a greater percentage of sample sites in the Liberty Reservoir watershed fell within forested land in the year 2000 than in 1995 and 1996 (Table 2).

Substantial changes in the proportion of sites within each of the three prominent land use types (Forest, Agriculture, and Urban) occurred between sample years in each of the study watersheds (Table 2 and Appendix C). The percentages of sites in forested areas within the Liberty Reservoir watershed increased by 10 % each sample year. The percentage of sites falling within agricultural land use remained relatively constant. However, the percentage of sites falling in urban areas in 1995 was substantially higher than in 1996 and 2000. Within the Mattawoman Creek watershed, the percentage of forested sites was similar between 1999 and 2000. Sites distributed in agricultural land use increased by 5% from 1999 and 2000. A greater percentage of sample sites were distributed in urban areas in 1999 than in 2000. The Prettyboy Reservoir watershed saw a slight increase in forested sites between 1996 and 2000, while the percentage of agricultural sites decreased by 27%. Sites within urban land use increased substantially between sample years.

Examining temporal trends in the ecological condition of the three watersheds is complicated by this variability in sample site distribution between sample years. Randomized site selection does not ensure an even distribution of sites among the four major types of land use within a watershed. The degree to which sites are aggregated within these land use types can change each year a watershed is sampled. What initially appears to be a considerable change in a variable of interest (i.e. nitrate concentration, instream habitat, FIBI, etc.) between sample years, may, in reality, be an artifact associated with an uneven distribution of sample sites within representative land use types. Additionally, trends in other measures of stream conditions within these CZM project watersheds may be difficult to detect due to differences in the spatial distribution of sample sites between sample years.

Table 2. Site Distribution Comparison: Percent of sample sites in land use types by year.

Liberty Reservoir Watershed			
	1995	**1996**	**2000**
	%	%	%
Forest	42	50	63
Agriculture	42	44	37
Urban	11	0	0
Wetlands	5	5	0
Barren	0	0	0

Mattawoman Creek Watershed			
		1999	**2000**
		%	%
Forest		77	80
Agriculture		5	10
Urban		18	10
Wetlands		0	0
Barren		0	0

Prettyboy Reservoir Watershed			
		1996	**2000**
		%	%
Forest		33	40
Agriculture		67	40
Urban		0	20
Wetlands		0	0
Barren		0	0

Annual Variability in Precipitation

The influence of monthly/annual precipitation variability on the characteristics of a stream is another factor that can complicate the detection of temporal changes in the ecological condition of streams in the three CZM watersheds. Annual and seasonal variability in precipitation and corresponding flow regimes can cause considerable fluctuations in the physical characteristics of stream ecosystems (Grossman et al. 1990). Nutrient concentrations, dissolved oxygen content, pH, and other components of water chemistry can vary greatly between flood and drought events. Additionally, stream channel morphology, substrate composition, and habitat availability can change in response to fluctuating flow rates. The abundance and composition of stream fish and invertebrate communities respond to these changes (Poff & Allan, 1995).

The majority of the variables and indices used by the MBSS in the assessment of watershed ecological condition may be affected by the variation in monthly and annual precipitation among sample years occurring within all three study watersheds. Water chemistry variables such as nitrate, dissolved oxygen content, and pH will fluctuate in response to variation in surface run-off and groundwater input associated with flood and drought events. Physical habitat metrics measured at each sample site could also be affected. Instream habitat quality, pool quality, and riffle quality may often change in response to water depth. The reduction of epifaunal substrate including woody debris, root wads, and gravel by scouring can occur during periods of high flows. Likewise, drought periods and subsequent drops in water level can expose woody debris and rootwads rendering this habitat useless to aquatic macro-invertebrates.

The fish and benthic macro-invertebrate indices of biotic integrity are stream assessment tools used to evaluate the biological integrity of a sample site based on the characteristics of the fish and macro-invertebrate assemblages (Roth et al. 1999). The community structure and abundance of stream fish and benthic macro-invertebrates can change in response to the chemical and physical habitat alterations that result from hydrological variability (Schlosser 1985, Poff & Allan 1995). Depending upon when the stream data are collected, the FIBI and BIBI calculated for a site may reflect recent responses to a hydrological event rather than or perhaps in addition to the effects of anthropogenic stressors. Index values for these sites may be altered by hydrologic variability and, potentially influence the overall ecological assessment of the watershed in which the stream site is located.

Monthly precipitation data were acquired from NOAA/ National Climatic Data Center for weather stations within or adjacent to the three CZM study watersheds. The percent monthly departure from 30-year averages was calculated for each sample year (Appendix B). Substantial variability in monthly precipitation between years occurred in all three watersheds. Of the three years that the Liberty Reservoir watershed was sampled, 1996 was the only year with consistently above average precipitation. Considerable flooding occurred in January of 1996 throughout the state of Maryland. Precipitation in 1995 and 2000 within this watershed was generally below the 30-year average. Annual precipitation was above average in the Mattawoman Creek watershed about half 1999 and 2000. Prettyboy Reservoir watershed experienced a relatively wet year in 1996, followed by a predominantly dry period in 2000.

While significant differences in parameter values between years are difficult to detect with only 2-3 years of data, subtle differences in values for some parameters are noticeable. This examination of the annual variability in site distribution and precipitation was used to assist in the interpretation of the results of year-to-year comparisons, even when significant differences between parameter values were not found.

Liberty Reservoir Watershed

Water Chemistry

Nitrate

There is no visible trend in nitrate concentrations in Liberty Reservoir watershed among the 1995, 1996, and 2000 sample years. Above average precipitation fell in January of 1996, followed by consistently dry months of February and March. This may have contributed to higher nitrate values in the samples collected in March of that year. Nitrate levels at all of the sites sampled in the three years had unnaturally elevated nitrate levels greater than 1mg/L (Roth et al. 1999).

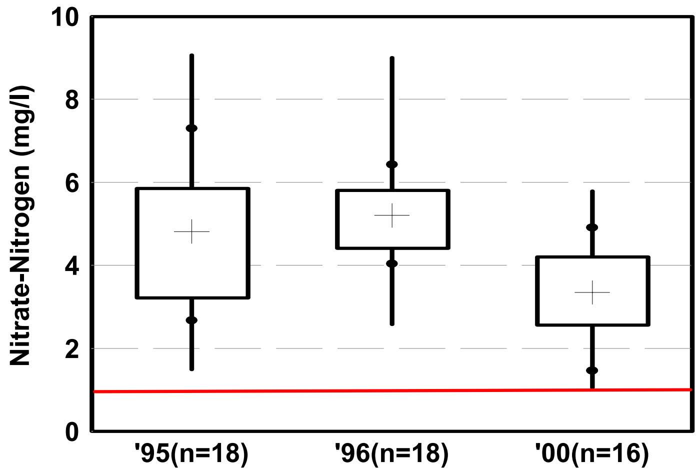

Figure 5a. Nitrate levels in Liberty Reservoir watershed in 1995, 1996, and 2000.

Dissolved Oxygen

Dissolved oxygen levels in Liberty Reservoir watershed exceeded the water quality criterion of 5mg/L at all sample sites (COMAR 1995). There were no significant differences in oxygen concentrations among the three sample years.

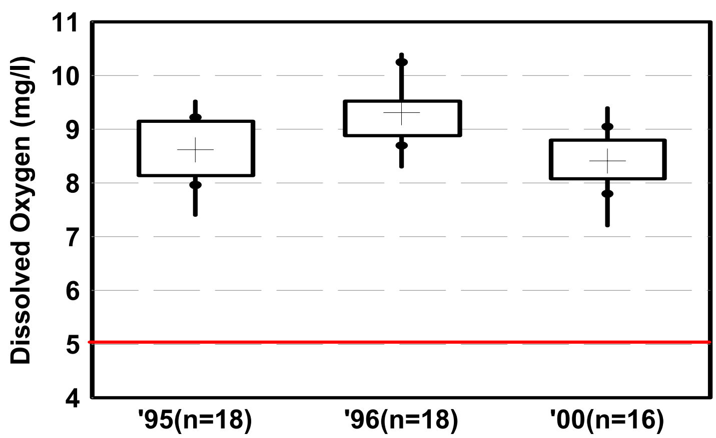

Figure 5b. Dissolved oxygen concentrations in Liberty Reservoir watershed in 1995, 1996, and 2000.

pH

All sites within Liberty Reservoir watershed met the water quality criterion standard of pH 6.0 for each of the three sample years (COMAR 1995). Of the three sources of acidity known to exist within Maryland (defined by Roth et. al. 1998), none was observed within this watershed. No significant changes in pH were detectable among sample years.

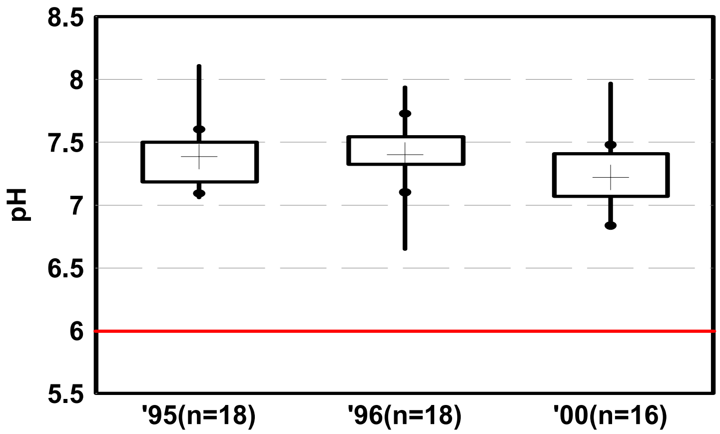

Figure 5c. pH in Liberty Reservoir watershed in 1995, 1996, and 2000.

Physical Habitat

Instream Habitat and Epifaunal Substrate

Yearly mean values for both instream habitat and epifaunal substrate increased slightly from 1996 to 2000. However, no significant differences among sample years were noticeable. Scores at greater than 50% of all sites sampled each year fell within the sub-optimal and optimal categories for both instream habitat and epifaunal substrate. The range of data for 1996 was consistently wider than in 1995 and 2000 for both parameters. This variability was perhaps the result of above average precipitation falling within that year. High stream flows associated with precipitation may have scoured benthic substrate and habitat, resulting in lower than usual epifaunal substrate and instream habitat scores.

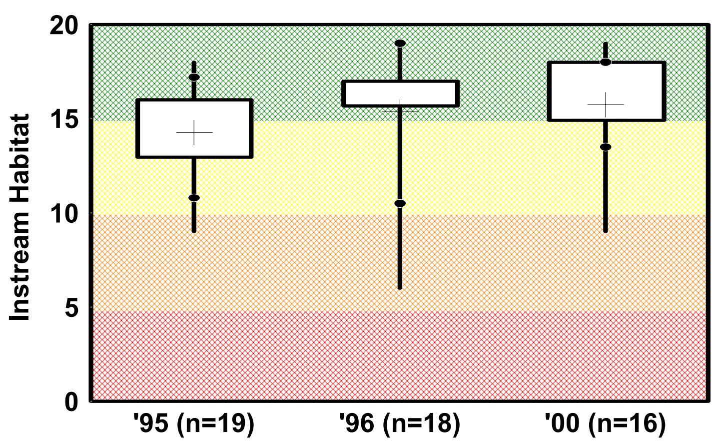

Figure 5d. Instream habitat quality in Liberty Reservoir watershed in 1995, 1996, and 2000.

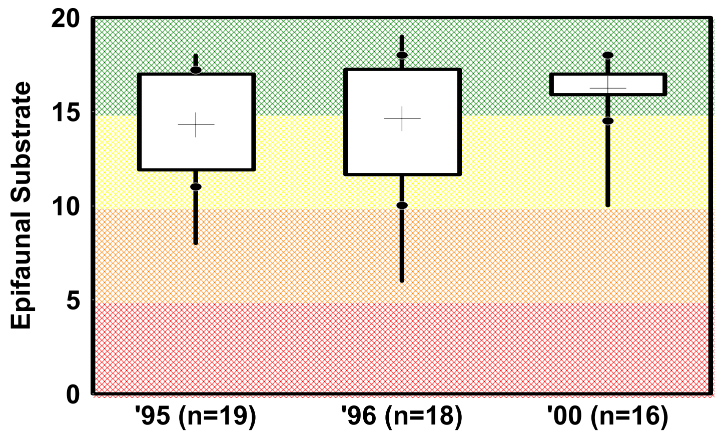

Figure 5e. Epifaunal substrate quality in Liberty Reservoir watershed in 1995, 1996, and 2000.

Pool and Riffle Quality

No significant differences in pool and riffle quality were detected among sample years. Mean values in 1996 were higher than in the two other sample years. Scoring for these parameters is influenced by water depth. Greater precipitation, and the associated increase in water depth occurring in 1996 may have skewed pool and riffle values higher than those found in 1995 and 2000. Greater than 50% of all sites sampled each year had sub-optimal and optimal riffle quality. Again, the differences in data ranges between sample years may be attributable to variability in precipitation.

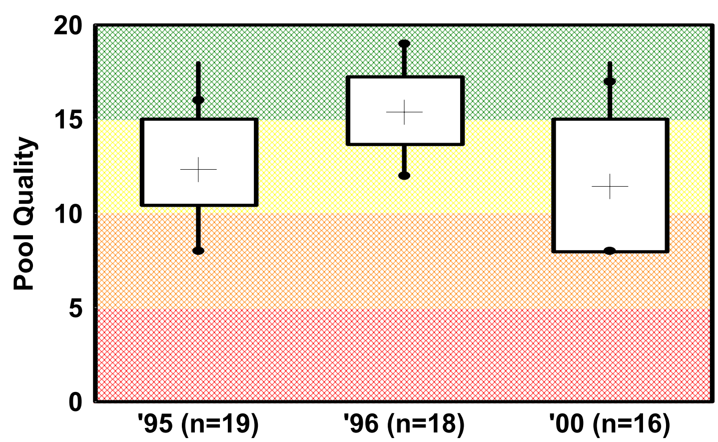

Figure 5f. Pool quality in Liberty Reservoir watershed in 1995, 1996, and 2000.

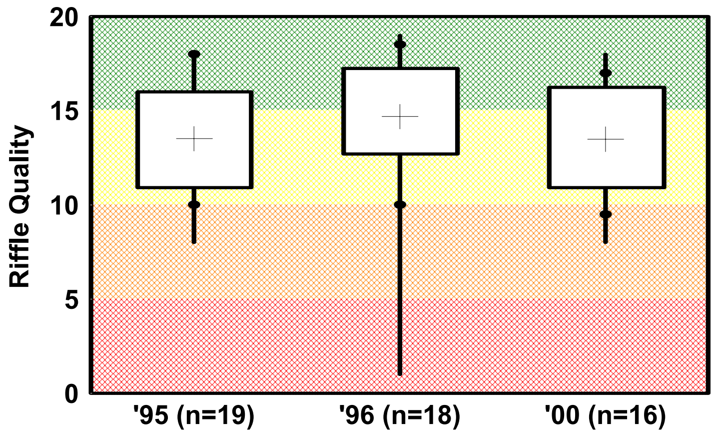

Figure 5g. Riffle quality in Liberty Reservoir watershed in 1995, 1996, and 2000.

Riparian Buffers

No apparent trends in riparian composition or buffer width were noticeable in the MBSS dataset for the three years the Liberty Reservoir watershed was sampled.   Any cumulative change in the number of stream miles buffered by riparian forest during the period between 1995 and 2000 could not be detected. Neither losses of riparian buffer by anthropogenic development nor gains in buffer were detectable.

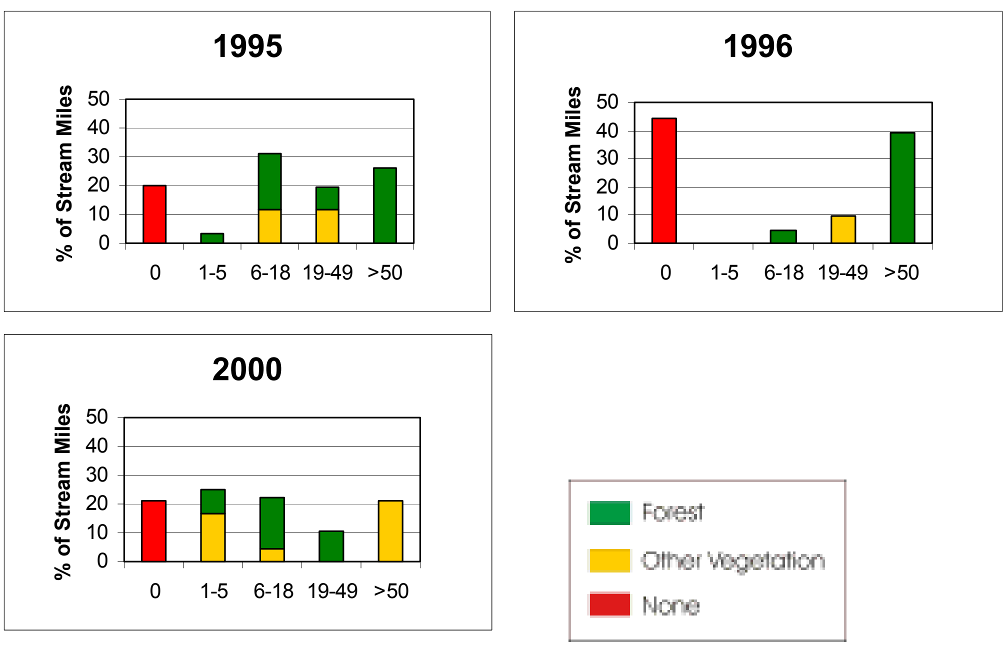

Figure 5h. Riparian buffer width and composition in Liberty Reservoir watershed in 1995, 1996, and 2000.

Biology

Benthic Index of Biotic Integrity (BIBI)

No significant differences in BIBI scores were detected among sample years. Scouring of bottom substrate and downstream sweeping of invertebrates by high stream flow rates may have caused the reduced BIBI scores in 1996. Mean BIBI values of 3.50 and 3.59 for 1995 and 2000, respectively, were similar.

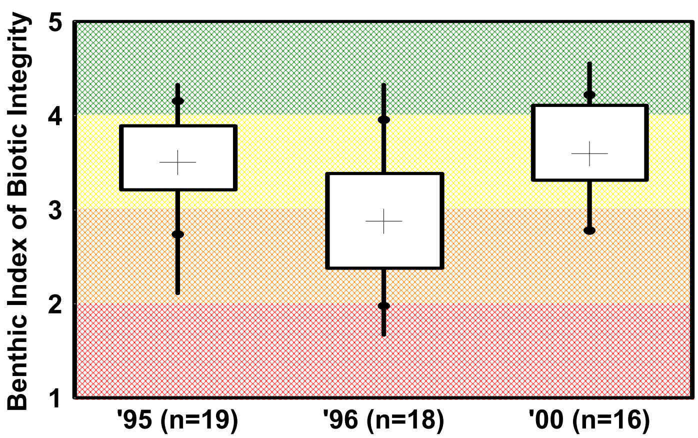

Figure 5i. BIBI in Liberty Reservoir watershed in 1995, 1996, and 2000.

Fish Index of Biotic Integrity (FIBI)

As in the BIBI, no significant differences in FIBI scores were apparent. Mean values were relatively constant and data ranges were similar among years. More than half of all sites sampled in the three years scored within the "good" and "fair" FIBI categories.

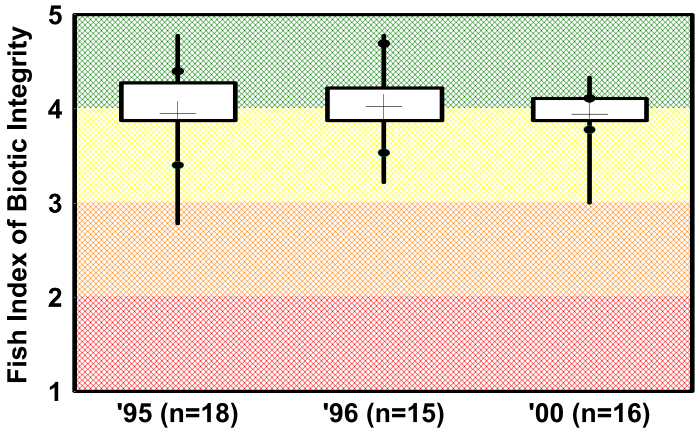

Figure 5j. FIBI in Liberty Reservoir watershed in 1995, 1996, and 2000.

Summary of Trends in Liberty ReservoirWatershed

Data collected during the three years of MBSS sampling within the Liberty Reservoir watershed yielded little conclusive evidence for a significant increase or decrease in stream conditions or anthropogenic stressors between 1995 and 2000. Although more sites in 1995 fell within urban land use, no apparent influences in annual differences in sample site distribution were apparent. Data for many of the physical habitat parameters in 1996 were more variable than in 1995 and 2000. Mean values and the distribution of data (25^{th} and 75^{th} percentiles) for nearly all chemical and physical parameters were elevated in 1996 when compared to the other two sample years. However, BIBI scores for 1996 were lower than 1995 and 2000. This pattern in the mean values for the majority of parameters supports the notion that above average precipitation in 1996 influenced the physical, chemical, and biological components of streams in Liberty Reservoir watershed more than any anthropogenic stressors..

Mattawoman Creek:

Water Chemistry

Nitrate

Nitrate levels were not significantly different between 1999 and 2000. However, nitrate concentrations were more variable in 1999 ranging from 0.0 to 2.69 mg/L. Greater than 90% of all sites sampled each year had nitrate concentrations below 1.0 mg/L, what is considered to be indicative of anthropogenic influence (Roth et al. 1999).

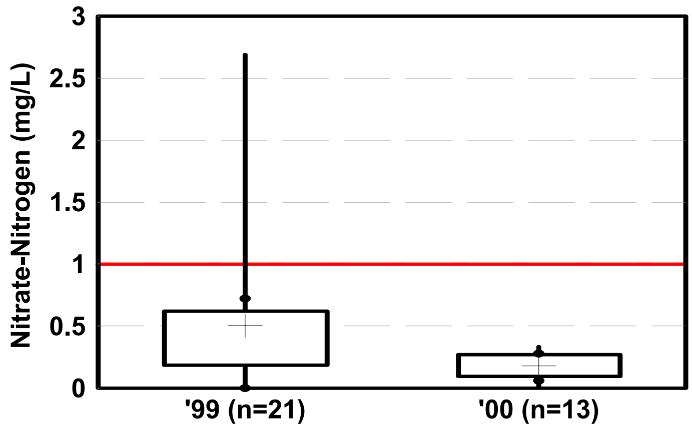

Figure 6a. Nitrate concentrations in Mattawoman Creek watershed in 1999 and 2000.

Dissolved Oxygen

No significant differences in dissolved oxygen concentrations were noticeable between sample years. Only 50% of sites sampled in 1999 had dissolved oxygen concentrations exceeding the water quality criterion of 5mg/L (COMAR 1995). As with the nitrate concentrations, variability between sample sites in 1999 was higher than site variability in 2000. All sites sampled in 2000 exceeded the water quality criterion.

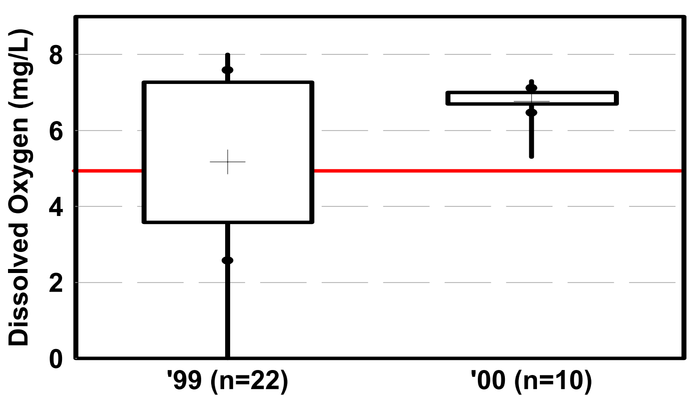

Figure 6b. Dissolved oxygen concentrations in Mattawoman Creek watershed in 1999 and 2000.

pH

pH values were not significantly different between sample years. 71% and 83% of the sample sites exceeded the water quality criterion (pH=6.0) in 1999 and 2000, respectively (COMAR 1995). Acidic deposition is the predominant source of acidity in streams within this watershed (Roth et. al. 1998).

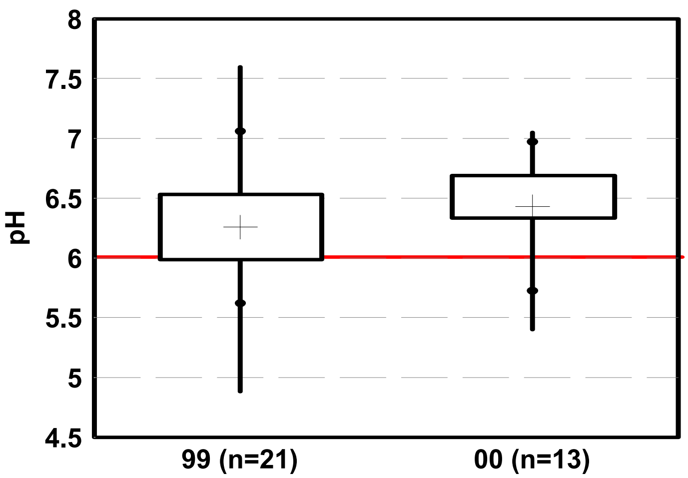

Figure 6c. pH in Mattawoman Creek watershed in 1999 and 2000.

<u>Physical Habitat</u>

Instream Habitat and Epifaunal Substrate

No significant differences in instream habitat or epifaunal substrate habitat assessment scores were apparent between sample years. Instream habitat and epifaunal substrate were more variable in 1999 than in 2000. Mean instream habitat in 2000 was higher than in 1999. This is perhaps a reflection of differences in site distribution between these years. A greater percentage of sites in 2000 fell into forested land use, while fewer sites were located in urban areas. This may have influenced instream habitat values.

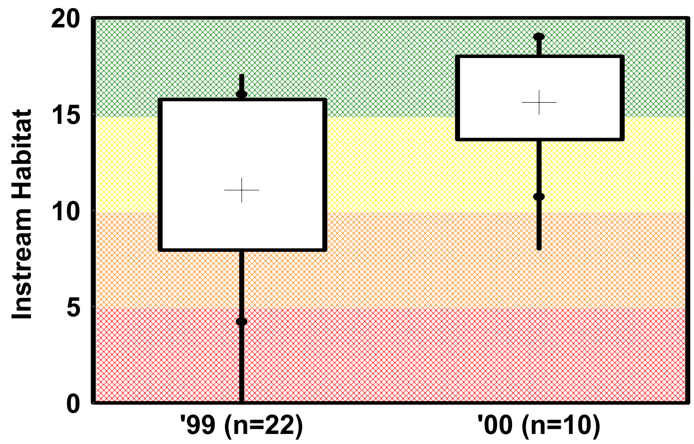

Figure 6d. Instream habitat quality in Mattawoman Creek watershed in 1999 and 2000.

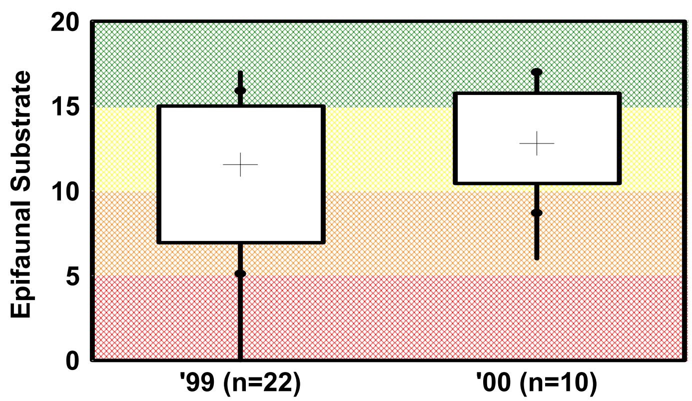

Figure 6e. Epifaunal substrate quality in Mattawoman Creek watershed in 1999 and 2000.

Pool and Riffle Quality

No significant differences in pool quality were apparent between 1999 and 2000. Mean values for both years fell within the sub-optimal category. Greater than 50% of all sites sampled in both years had sub-optimal or optimal pool quality. Variability in 1999 was higher than in 2000.

Riffle quality for both years was low, with 73% and 50% of sites scoring in the marginal and poor categories in 1999 and 2000, respectively. No significant differences were detected between years. The range of scores between years was similar, but the 25th and 75th percentile interval was much narrower in 2000.

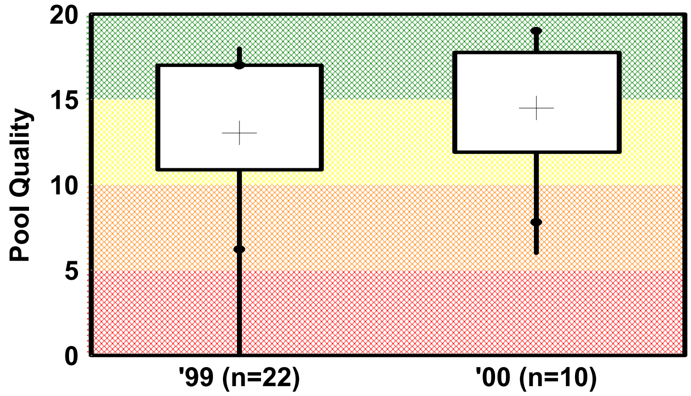

Figure 6f. Pool quality in Mattawoman Creek watershed in 1999 and 2000.

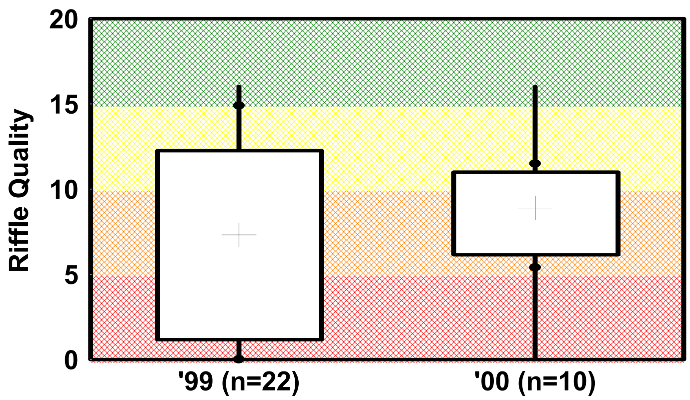

Figure 6g. Riffle quality in Mattawoman Creek watershed in 1999 and 2000.

Riparian Buffers

There were differences in riparian width between 1999 and 2000. An estimated 20% more stream miles in 1999 had no riparian buffer than in 2000. Riparian composition varied between sample years as well. These changes may be attributable to sample site distribution. What first appear to be trends in riparian buffers may in fact be year to year changes in site location in respect to land use.

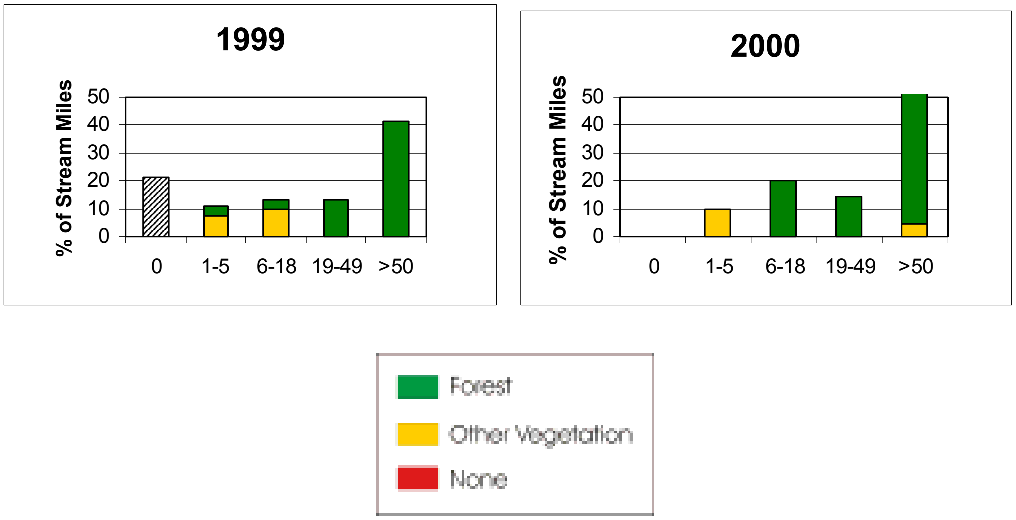

Figure 6h. Riparian buffer widths and composition in Mattawoman Creek watershed in 1999 and 2000.

Biology

Benthic Index of Biotic Integrity (BIBI)

No significant differences in BIBI values were apparent between years. BIBI values ranged through all categories in 1999 and 2000, with more than half of the sites scoring within the fair and poor categories.

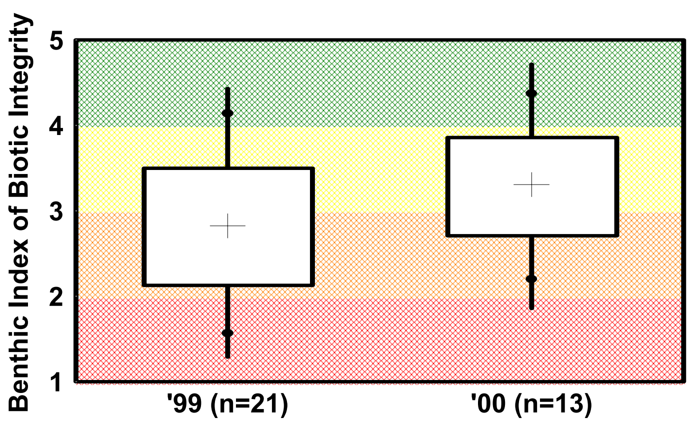

Figure 6i. BIBI in Mattawoman Creek watershed in 1999 and 2000.

Fish Index of Biotic Integrity (FIBI)

Mean FIBI values for both years fell into the poor category. No significant differences between years were found. FIBI values for 1999 were more variable than for sites sampled in 2000.

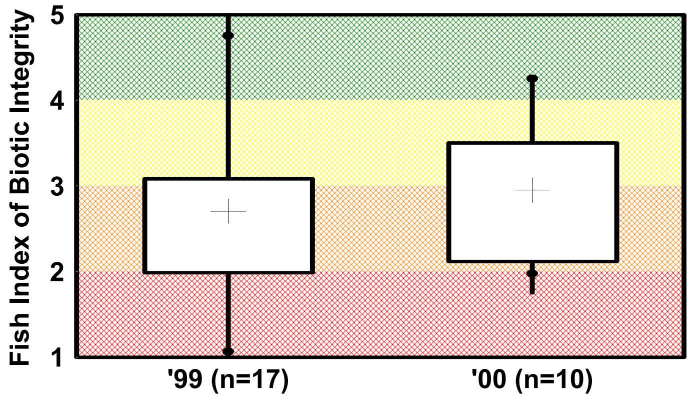

Figure 6j. FIBI in Mattawoman Creek watershed in 1999 and 2000.

Summary of Trends in Mattawoman Creek Watershed

No significant trends in anthropogenic impacts between 1999 and 2000 were detected. Data ranges for all chemical, physical, and biological parameters were wider in 1999 than in 2000. Greater variability in data from 1999 may be at least partially explained by differences in sample site distribution between the two sample years. Fewer forested sites were sampled in 1999, and a greater percentage of sites fell into urban areas than in 2000. Lower scores attributable to urban impacts may have introduced variability in parameter data for 1999.

Prettyboy Reservoir Watershed

Water Chemistry

Nitrate

Nitrate concentrations were similar in 1996 and 2000 sample years in Prettyboy Reservoir streams. All sites sampled in both years had elevated nitrate levels originating from anthropogenic sources (Roth et al. 1999).

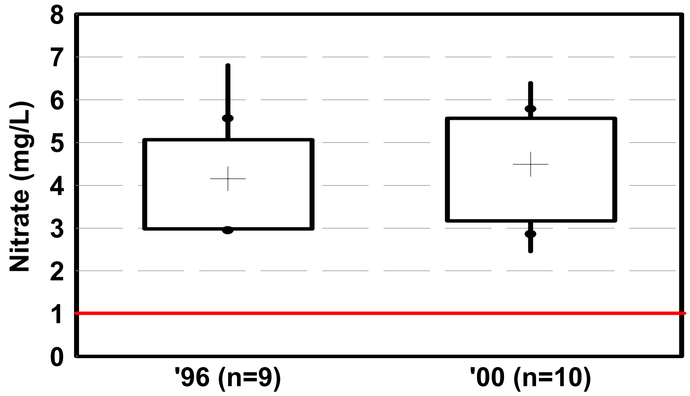

Figure 7a. Nitrate concentrations in Prettyboy Reservoir watershed in 1996 and 2000.

Dissolved Oxygen

Dissolved oxygen concentrations were significantly different between 1996 and 2000. From this data, dissolved oxygen appears to be declining in Prettyboy watershed. Continued water quality monitoring is warranted to track dissolved oxygen concentrations in future years. Another possible explanation for lower oxygen values in 2000 is that annual precipitation in 1996 was 33% above average. High stream flow rates potentially elevated oxygen concentrations above normal during 1996. All sites sampled during both years had oxygen concentrations exceeding the water quality criterion of 5 mg/L (COMAR 1995).

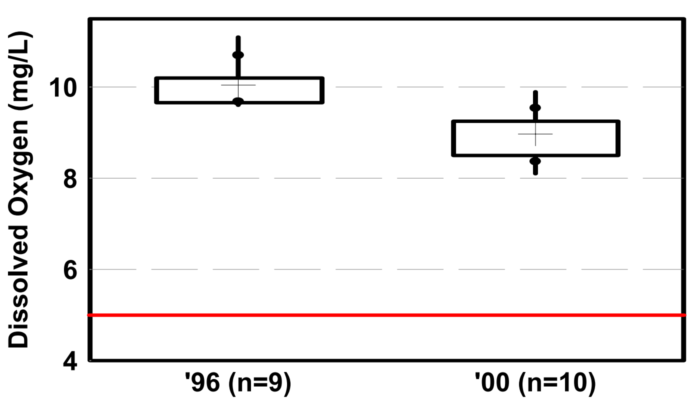

Figure 7b. Dissolved oxygen concentrations in Prettyboy Reservoir watershed in 1996 and 2000.

pH

No significant difference in pH between years was apparent. Variability was minimal in 2000. All sites within Prettyboy Reservoir met the water quality criterion standard of pH 6.0 in 1996 and 2000 (COMAR 1995).

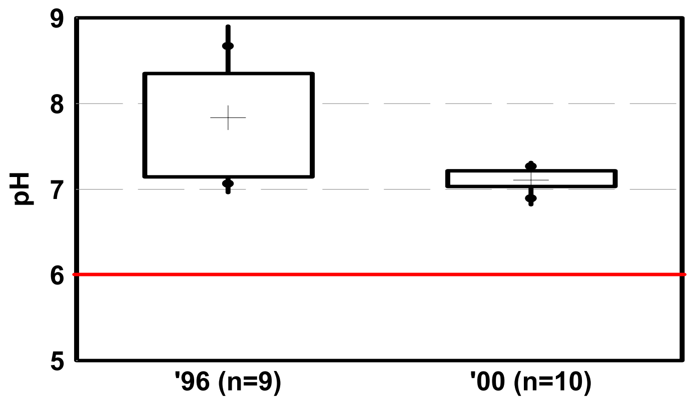

Figure 7c. pH in Prettyboy Reservoir watershed in 1996 and 2000.

<u>Physical Habitat</u>

Instream Habitat and Epifaunal Substrate

No significant differences between years were detected for instream habitat and epifaunal substrate. Greater than 50% of all sites sampled each year scored in the sub-optimal and optimal categories for both habitat parameters. Mean values and variability between years for both parameters were relatively constant.

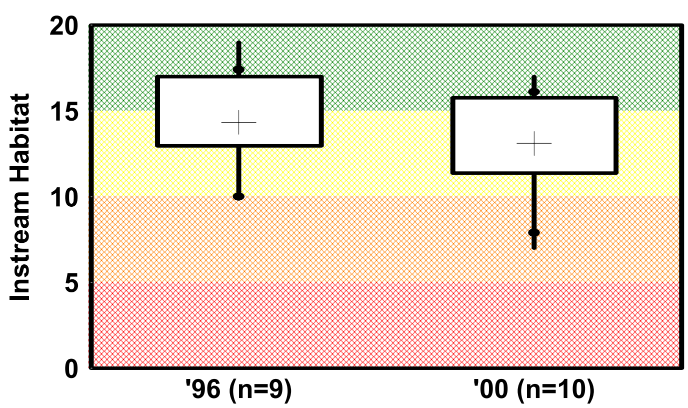

Figure 7d. Instream habitat quality in Prettyboy Reservoir watershed in 1996 and 2000.

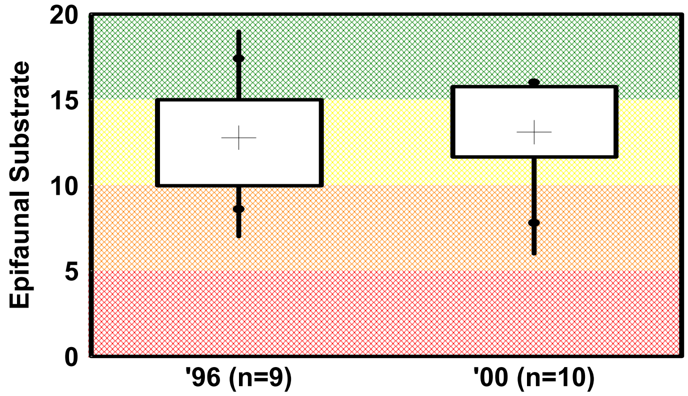

Figure 7e. Epifaunal substrate quality in Prettyboy Reservoir watershed in 1996 and 2000.

Pool and Riffle Quality

There was no significant difference in pool quality between 1996 and 2000. Mean scores for each year fell within the sub-optimal category. More than half of all sites sampled in each year had epifaunal substrate scores within sub-optimal and optimal categories. Variability was similar between years.

No significant difference in riffle quality between years was apparent. More than half of all sites sampled in each year had epifaunal substrate within sub-optimal and optimal categories. Mean riffle values fell within the optimal category each sample year. Riffle quality for 1996 was more variable than in 2000.

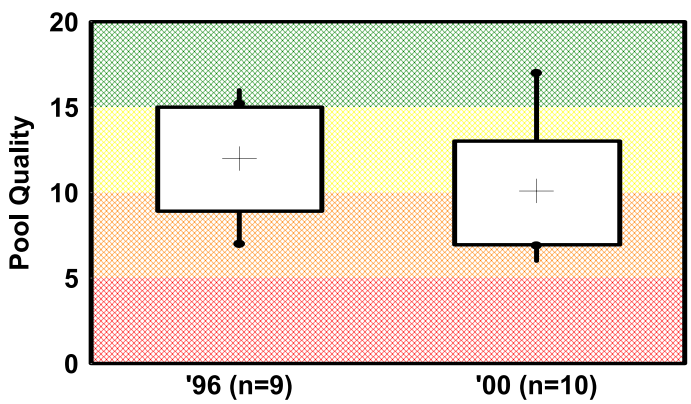

Figure 7f. Pool quality in Prettyboy Reservoir watershed in 1996 and 2000.

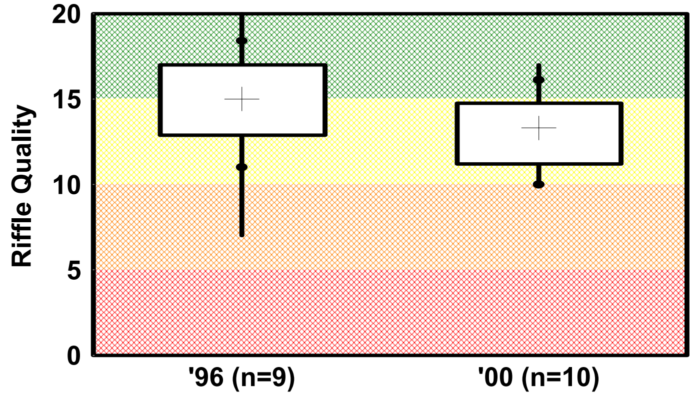

Figure 7g. Riffle quality in Prettyboy Reservoir watershed in 1996 and 2000.

Riparian Buffer

Riparian buffer composition and width varied considerably between the two sample years. A greater percentage (approximately 30%) of stream miles in 2000 had buffer widths > 50 meters than in 1996. This difference may reflect the 7% increase in sites falling in forested land use and a 27% drop in sites falling in agricultural land use in 2000. Riparian composition also varied between years. Forests dominated the buffers of sites within 2000. Other vegetation types dominated the buffers in 1996. Again, this may be explained by differences in sample site distribution between years.

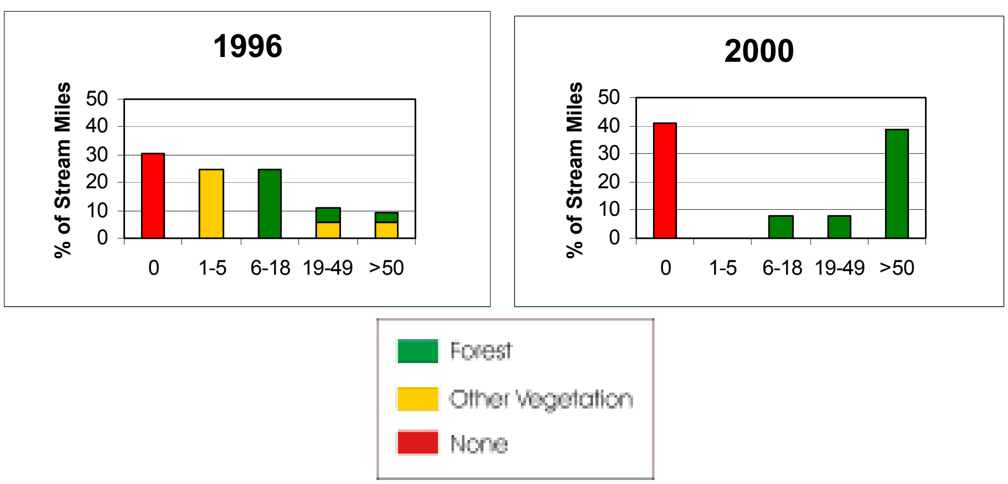

Figure 7h. Riparian buffer widths and composition in Prettyboy Reservoir watershed in 1996 and 2000.

Biology

Benthic Index of Biotic Integrity (BIBI)

No significant differences in BIBI scores between years were detected. Mean BIBI scores between years varied, but both fell within the fair category. Higher precipitation/stream flow rates in 1996 may have reduced BIBI scores for that year. Variability between years is similar. BIBI scores do not reflect the possible decline in water quality indicated in dissolved oxygen readings in 2000. This finding warrants further investigation.

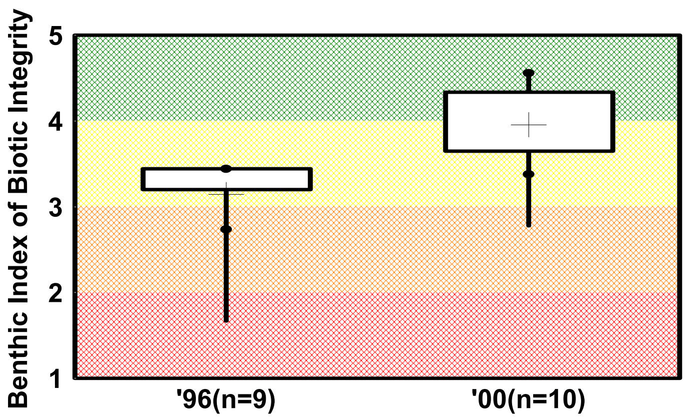

Figure 7i. BIBI in Prettyboy Reservoir watershed in 1996 and 2000.

Fish Index of Biotic Integrity (FIBI)

No significant differences in FIBI scores between years were detected. Greater than 50% of the sites sampled in each year scored within the fair and good FIBI categories. The range of values was greater in 2000 (1.44-5.0) than in 1996 (3.44-4.33) and is consistent with the lower dissolved oxygen values measured in 2000.

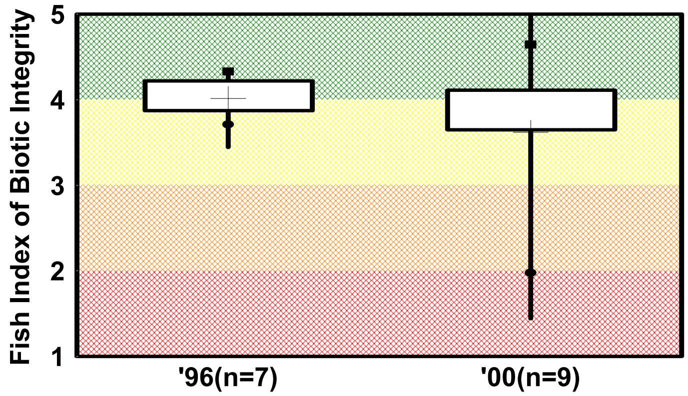

Figure 7j. FIBI in Prettyboy Reservoir watershed in 1996 and 2000.

Summary of Trends in Prettyboy Reservoir

Significant differences in dissolved oxygen concentrations and subtle changes in physical habitat parameters between 1996 and 2000 point to possible declines in water quality in the Prettyboy Reservoir watershed. However, these differences could not be directly linked to anthropogenic causes.

Conclusion

With the exception of dissolved oxygen concentrations in Prettyboy Reservoir watershed, no significant trends were detected in the ecological conditions of non-tidal streams in the three CZM watersheds. The lack of significant evidence for temporal trends in the ecological conditions of the three CZM project watersheds was not unexpected. Separation of actual trends from random annual variability in watershed conditions using only two or three years of ecological data is difficult. Subtle, non-significant differences in the ten parameters within each watershed may partially be explained by differences in sample site distributions and precipitation occurring between years. These confounding factors tend to mask temporal trends in watershed condition associated with anthropogenic influences.

To more conclusively ascertain whether or not the ecological conditions within the three CZM watersheds are improving or declining as a result of anthropogenic activity and resource management actions, or are unchanged, we recommend the following: 1) Acquire data across multiple sample years (at least 5). A longer time series of data is necessary to separate yearly variability induced by annual precipitation differences from actual trends in the conditions of streams across a watershed. 2) Establish stationary sample sites within each watershed to be sampled each year. Yearly sampling of these sites would reveal annual variability at site locations. A combination of these stationary sites with randomly- selected sites could help to differentiate meaningful temporal changes occurring throughout the watershed. 3) Obtain current land use information for each year that the streams in a CZM project watershed are sampled. This would allow comparisons of land use between sample years. Quantifiable land use data from each sampling year could then be related to changes occurring in the chemical, physical, and biological conditions within a watershed.

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Appendix A. Thresholds for classifying physical habitat, chemical, and biological values as indicative of degradation or good quality, rare, or unique stream resources.

A-1. Fish and Benthic Indices of Biotic Integrity. Narrative descriptions of stream biological integrity associated with each of the IBI categories		
Good	IBI score 4.0 - 5.0	Comparable to reference streams considered to be minimally impacted. Scores fall within the upper 50% of reference site conditions.
Fair	IBI score 3.0 - 3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. Scores fall within the lower portion of the range of reference sites (10th to 50th percentile).
Poor	IBI score 2.0 - 2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating some degradation. Scores fall below the 10^{th} percentile of reference site conditions.
Very Poor	IBI score 1.0 - 1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation.

A-2. Dissolved Oxygen (DO). The state water quality criterion for DO is greater than 5.0 mg/L (COMAR 1997).

A-3. pH. The state water quality criterion for pH is 6.5 (COMAR 1997).

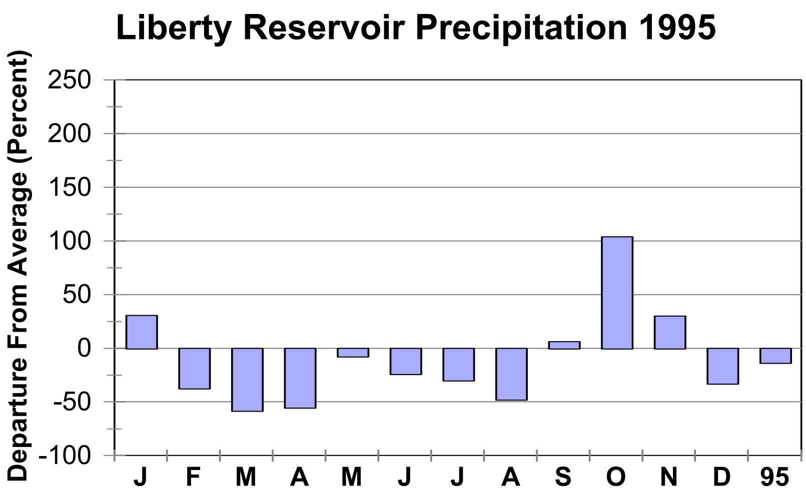
A-4. Nitrate. Nitrate concentrations exceeding 1.0 mg/L are considered indicative of anthropogenic influence (Roth et al. 1999).

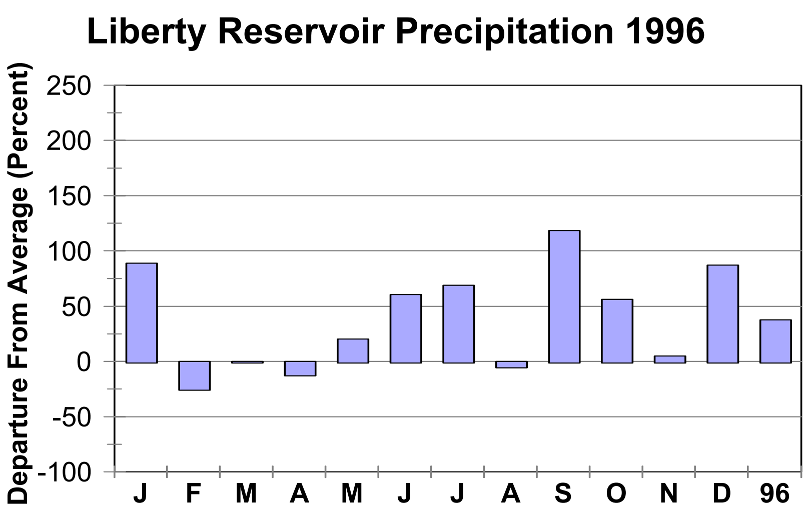
A-5. Habitat Assessment.

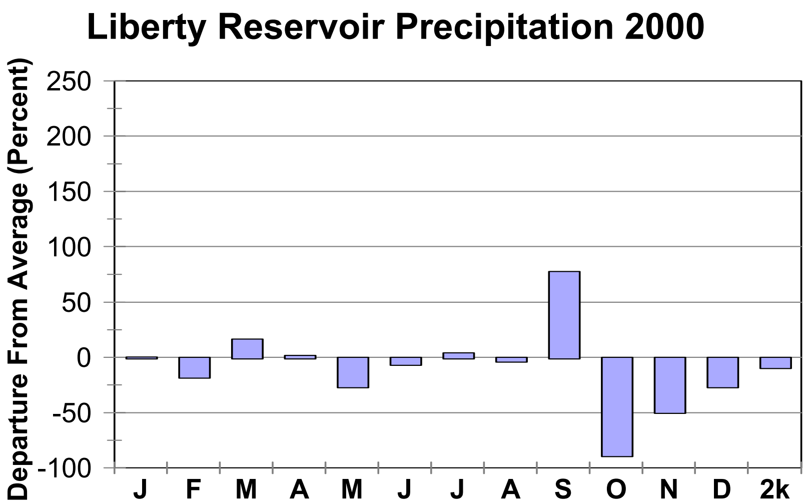
MBSS Stream Habitat Assessment Guidance				
Habitat Parameter	**Optimal 16-20**	**Sub-Optimal 11-15**	**Marginal 6-10**	**Poor 0-5**
Instream Habitat	Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, rootwads, aquatic plants, or other stable habitat	30-50% of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat avail-ability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
Epifaunal Substrate	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abund. of cobble with gravel &/or boulders common; or woody de-bris, aquatic veg., under-cut banks, or other pro-ductive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
Pool/Glide/ Eddy Quality	Complex cover/&/or depth > 1.5 m; both deep (> .5 m)/shallows (< .2 m) present	Deep (>0.5 m) areas present; but only moderate cover	Shallows (<0.2 m) prevalent in pool/glide/eddy habitat; little cover	Max depth <0.2 m in pool/glide/eddy habitat; or absent completely
Riffle/Run Quality	Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g. cobble, boulder) & variety of current velocities	Riffle/run depth generally 5-10 cm, variety of current velocities	Riffle/run depth generally 1-5 cm; primarily a single current velocity	Riffle/run depth < 1 cm; or riffle/run substrates concreted

Appendix B: Monthly precipitation by year for each CZM watershed. Bars represent the percent departure from 30-year averages by month. Annual departure from 30-year averages for each watershed are also represented (designated by 95, 96, and 2k).

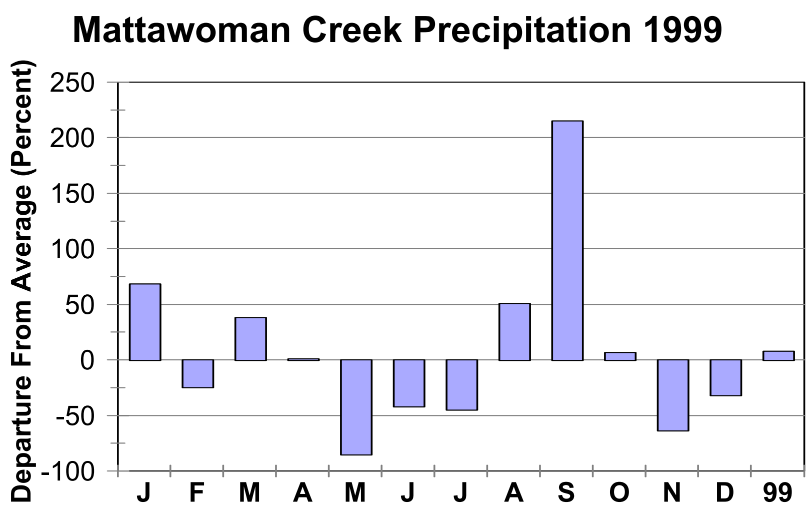
B-1:

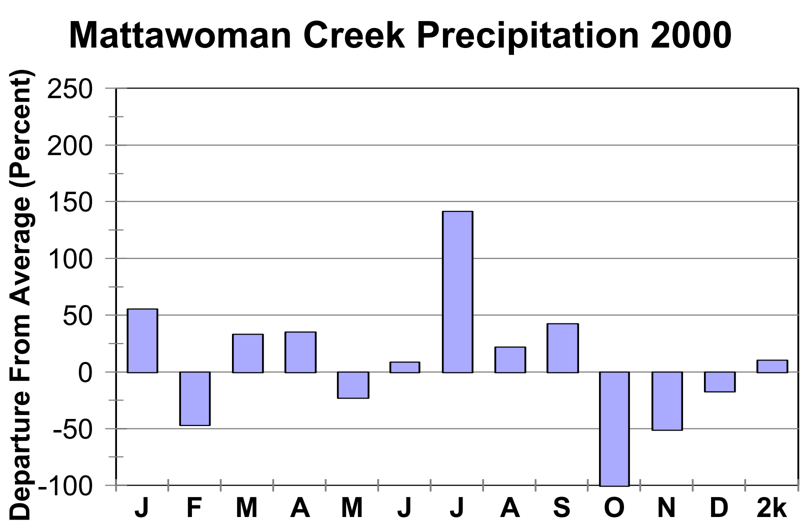




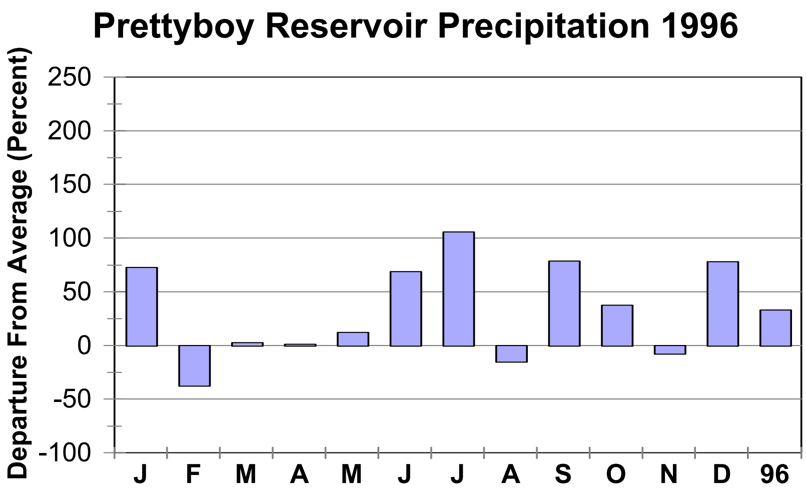

Liberty Reservoir Precipitation 2000
Departure From Average (Percent)
250
200
150
100
50
0
-50
-100
J F M A M J J A S O N D 2k

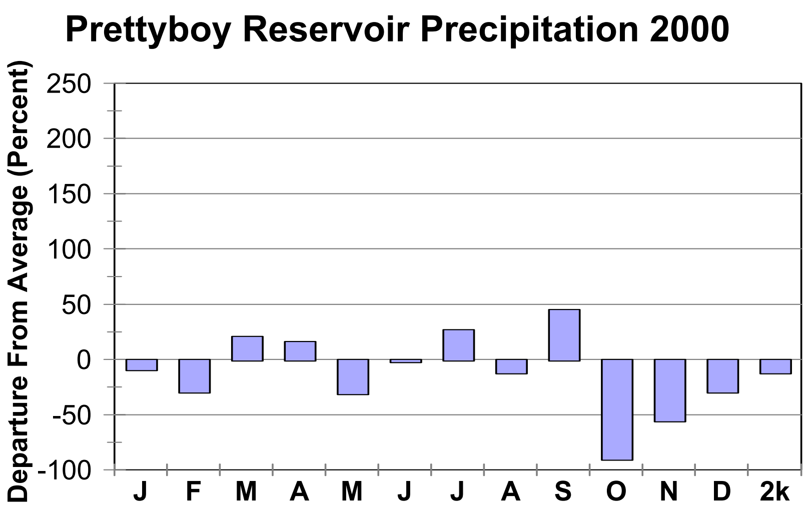
B-2:


Mattawoman Creek Precipitation 1999
Departure From Average (Percent)
250
200
150
100
50
0
-50
-100
J F M A M J J A S O N D 99


Mattawoman Creek Precipitation 2000
Departure From Average (Percent)
250
200
150
100
50
0
-50
-100
J F M A M J J A S O N D 2k

B-3:


Prettyboy Reservoir Precipitation 1996
Departure From Average (Percent)
250
200
150
100
50
0
-50
-100
J
F
M
A
M
J
J
A
S
O
N
D
96


Prettyboy Reservoir Precipitation 2000
Departure From Average (Percent)
250
200
150
100
50
0
-50
-100
J
F
M
A
M
J
J
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O
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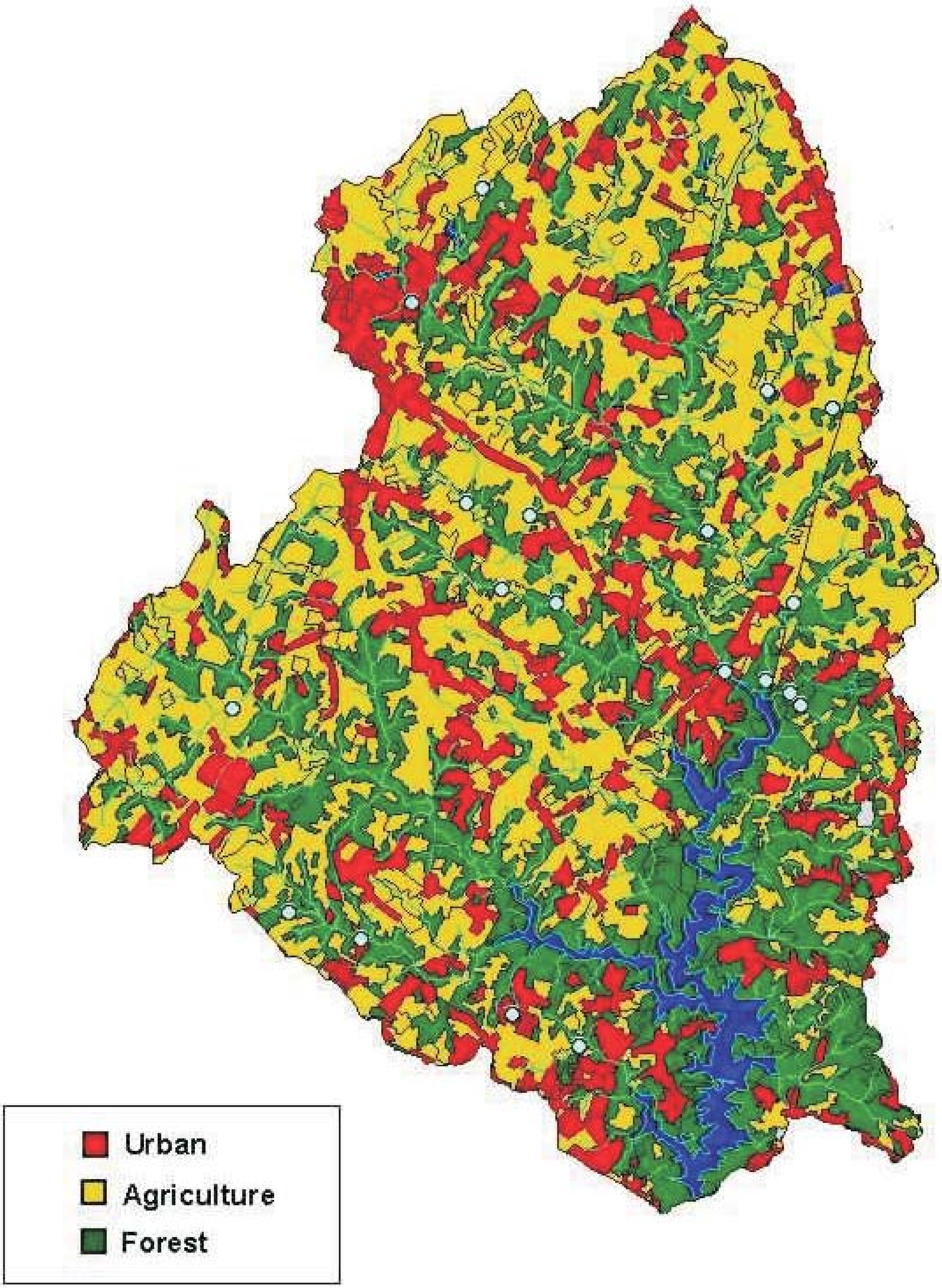
D
2k

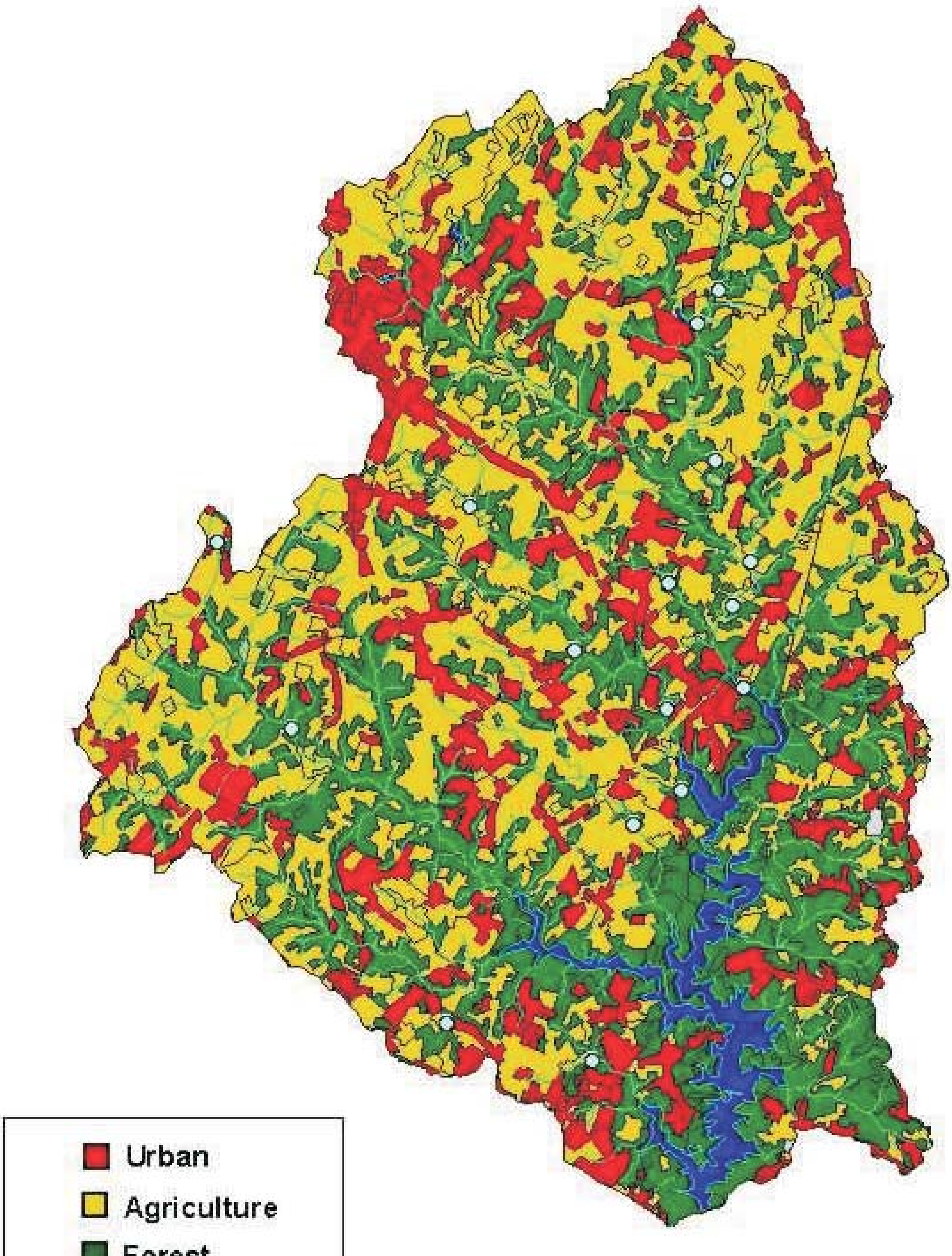
Appendix C-1:

The Spatial Distribution of Sites Sampled in Liberty Reservoir Watershed in 1995.



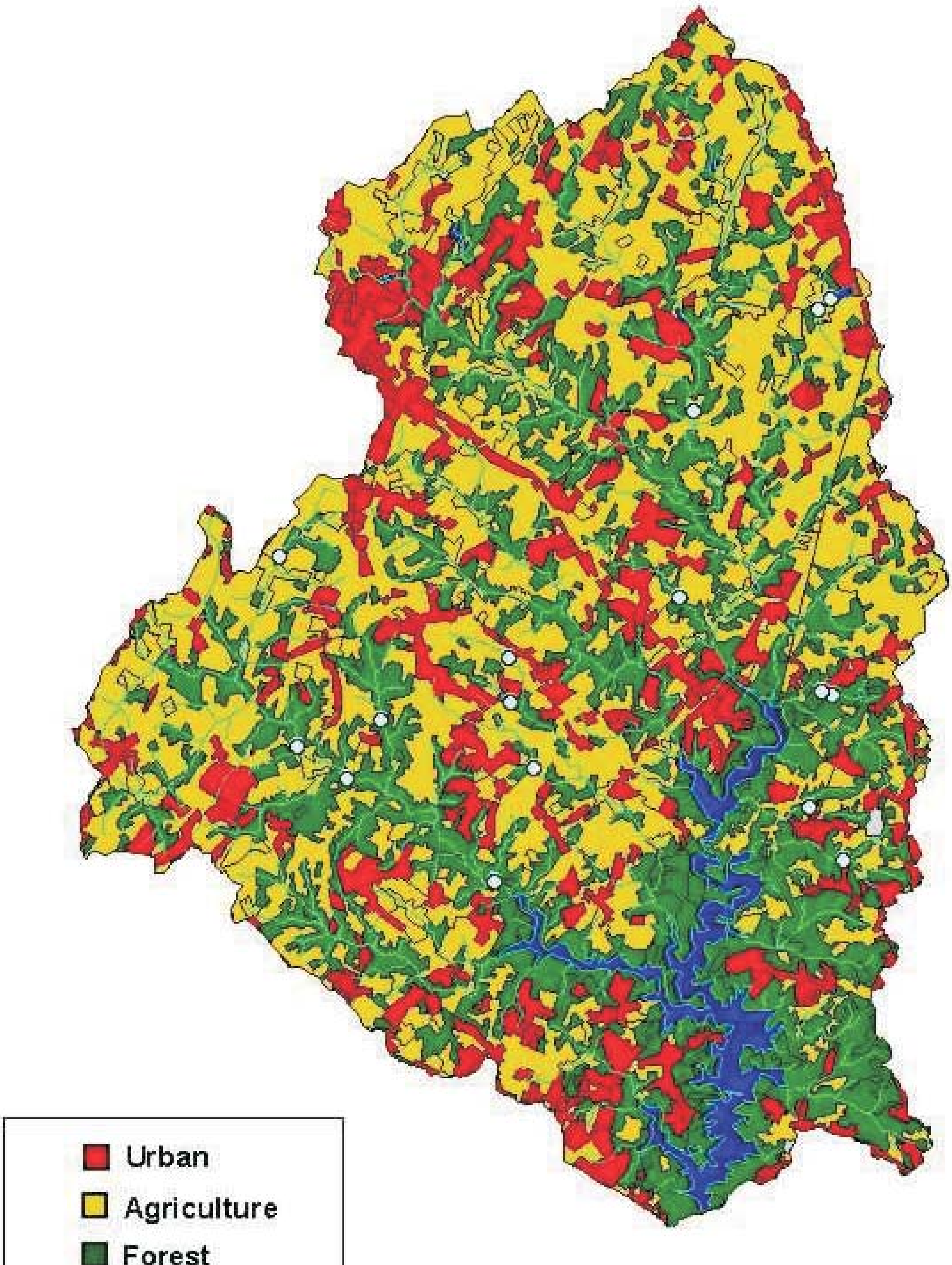
C-2:

The Spatial Distribution of Sites Sampled in Liberty Reservoir Watershed in 1996.

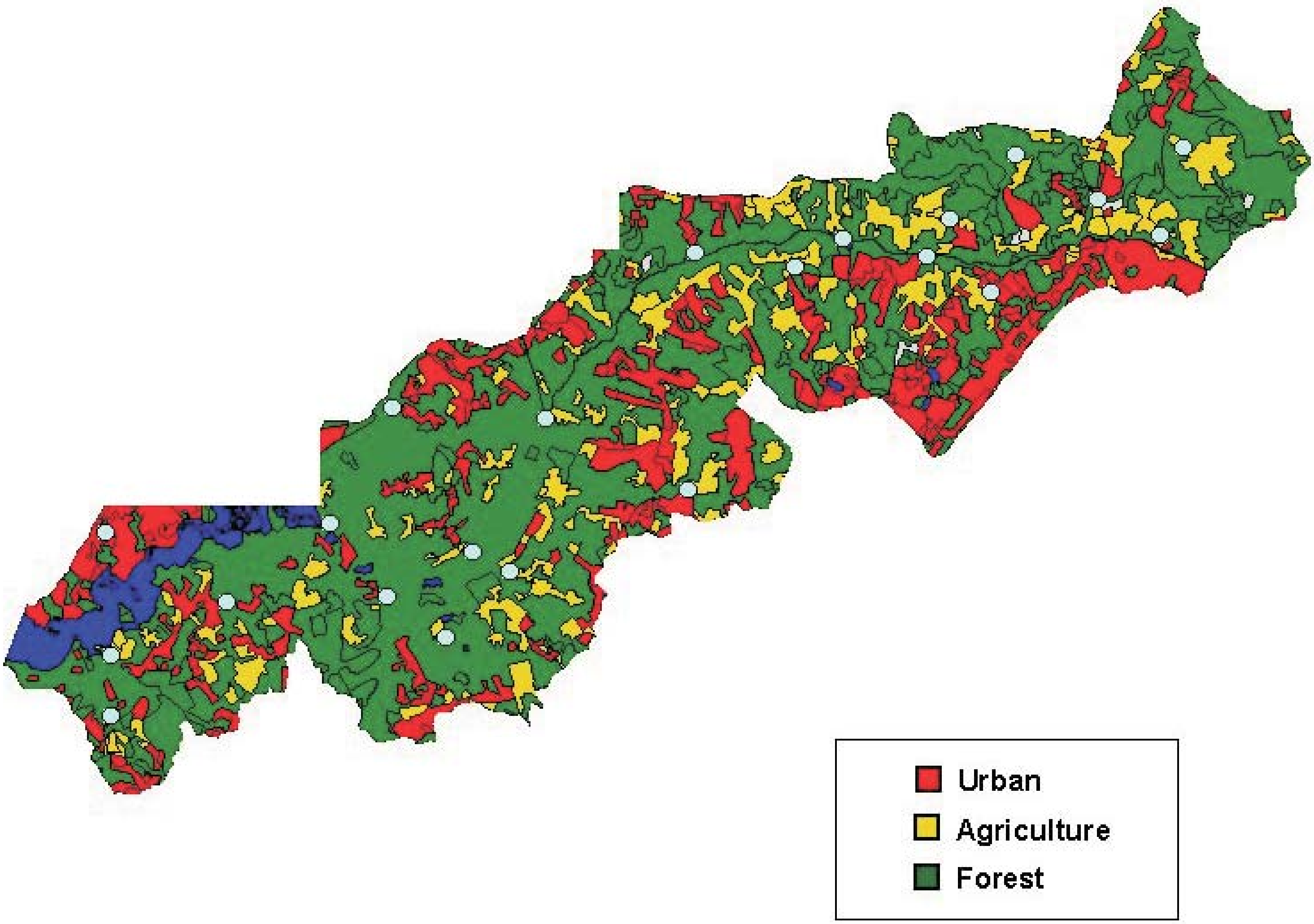


C-3:

The Spatial Distribution of Sites Sampled in Liberty Reservoir Watershed in 2000.

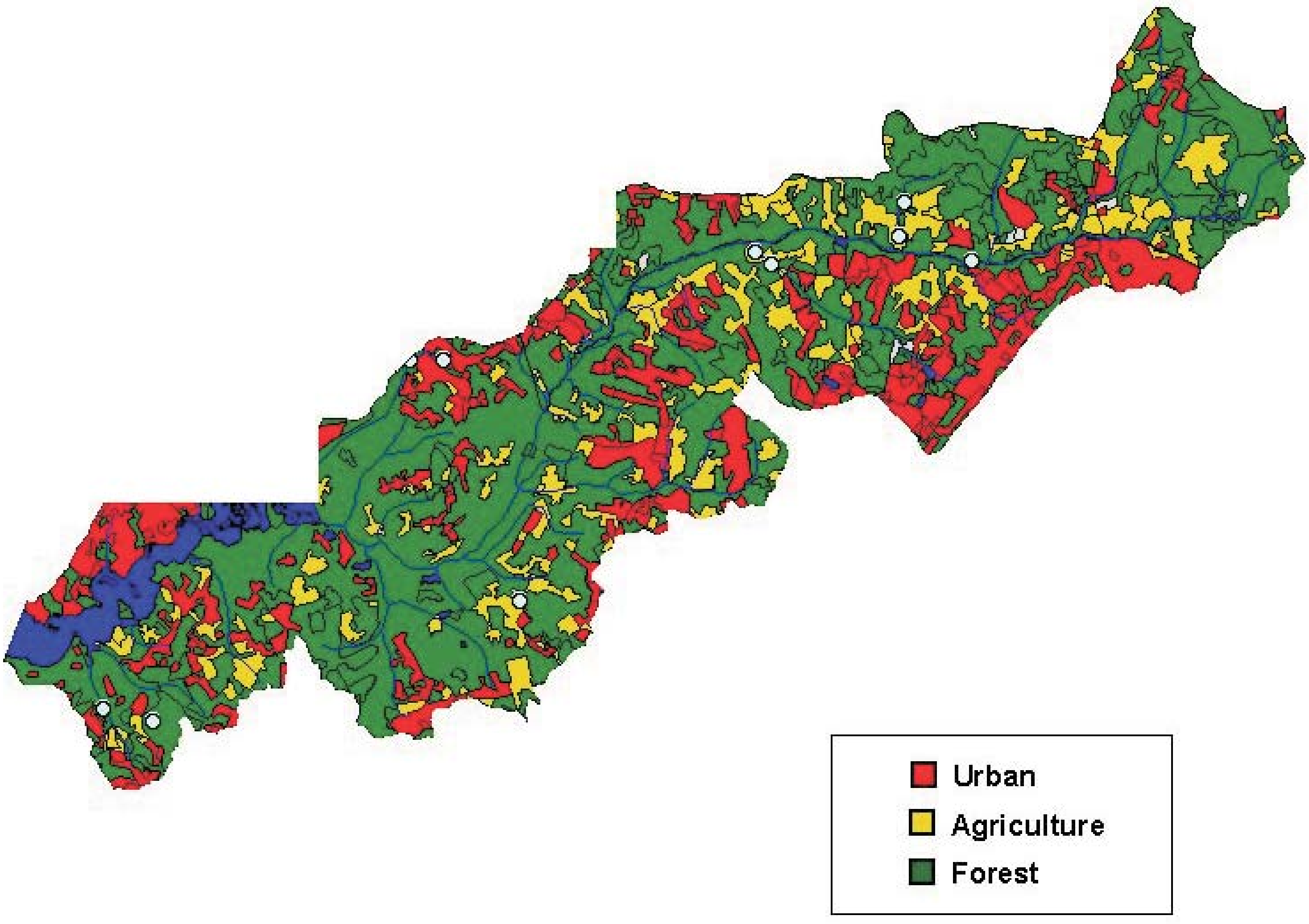


The Spatial Distribution of Sites Sampled in Mattawoman Creek Watershed in 1999.



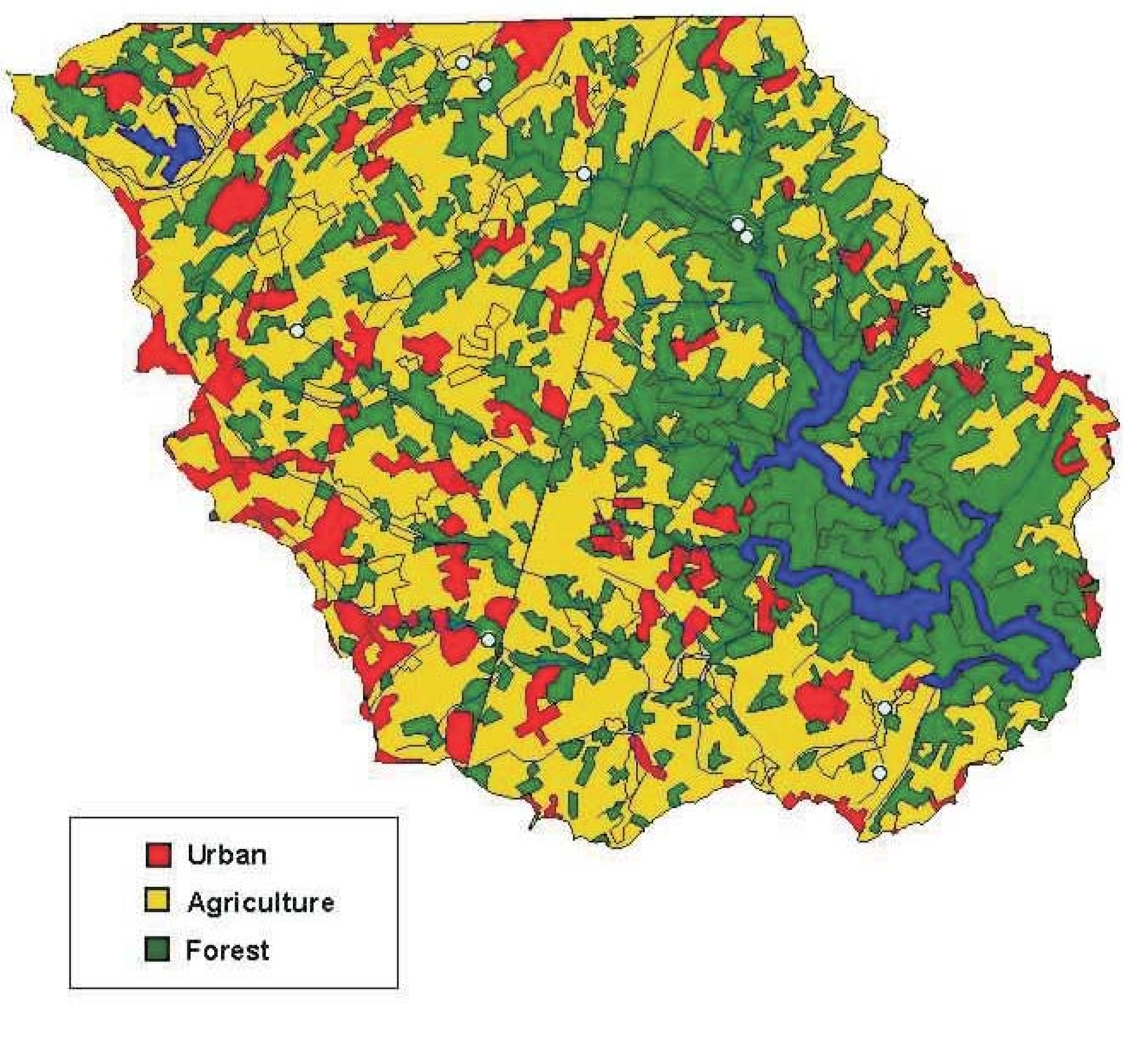
C-5:

The Spatial Distribution of Sites Sampled in Mattawoman Creek Watershed in 2000.



C-6:

The Spatial Distribution of Sites Sampled in Prettyboy Reservoir Watershed in 1996.



C-7:

The Spatial Distribution of Sites Sampled in Prettyboy Reservoir Watershed in 2000.